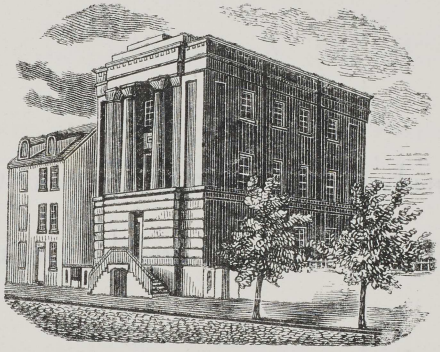
AN ESSAY ON

The Process of Digestion

RESPECTFULLY SUBMITTED TO THE FACULTY OF THE



HOMŒOPATHIC MEDICAL COLLEGE

OF PENNSYLVANIA,

On the day of ~~January~~ February, Eighteen Hundred and Fifty-~~six~~ Seven

By George H. Taft

Of Rhode Island

The Proceds of Digestion.

"Obstupeo, et memet lactâ formidine lustro
Divini monumentum operis!"

The human body has always been an object of admiration, wonder and praise. The Psalmist who could look upon it only as a Symmetrical whole, knowing nothing of its composition or of the complex arrangement of its different parts; Says, in one of his songs of praise, "I will praise thee for I am fearfully and wonderfully made." — How much more extensive is the field that is opened to the admiration of the medical philosopher of the present day.

We see at a glance the symmetry and grace of person that so won the admiration of the Psalmist; but the Scalpel and microscope have disclosed new wonders to his vision. The Scalpel has laid open the inmost recesses of

the body, bringing to light the various structures of which it is composed and the organs by which these structures are nourished and maintained in condition for performing their functions. The microscope has extended the view still farther by disclosing the ultimate structure of every part of the human organism. Among the wonders thus revealed to the student of medecine, it becomes a source of perplexity to choose the most important or interesting as the subject of an essay. We have chosen for our consideration "The Process of Digestion" for the reason that in the progress of our medical studies it has always proved an interesting subject to us, and seems, in a manner to hold dominion over all the other

functions of the body. — Let us then commence the consideration of our subject by inquiring. What is Digestion?

Digestion is that process by which the nutrient and calorifacient matters are separated from the food and rendered fit for absorption. (Definition of Digestion)

This separation is brought about mainly by by chemical agencies which are aided by the mechanical operations of the teeth.

As the object of digestion is to procure a proper pabulum to repair the waste of tissue and to support the combustive process and as different portions of the digestive apparatus have distinct parts to play in these operations, we will divide our subject into two parts, the first of which we will call histogenetic and the second calorifacient digestion.

(Histogenetic Digestive

The digestive apparatus consists of a long canal of varying dimensions, commencing at the mouth and terminating at the anus. The prominent portions of the canal, are, the mouth, pharynx and oesophagus, stomach, small and large intestine. We may mention as accessory organs, the salivary glands, liver and pancreas. To begin at the commencement of the digestive process, we find that the food after being received into the mouth, is subjected to the twofold operation of mastication and insalivation. Mastication is purely a mechanical act having for its object the breaking up of the food. The tongue by its motions exposes every portion of the mass to their action and while it is thus ~~thus~~ triturated by the teeth, it becomes thor-

oughly saturated with the salivary secretions. Before we pass on farther let us pause for awhile to consider the composition and uses of the saliva. This fluid is secreted by three pairs of glands; the parotid which is the largest and opens into the mouth through the duct of Steno, the submaxillary which has Wharton's duct, and the sublingual which has a number of little orifices near the frenum linguae. The specific gravity of the mixed secretions of these glands varies from 1.004 to 1.009. — Analyses have shown that is composed mainly of water with the addition of an organic element called ptyaline, with fatty matters, mucus and fixed salts. The secretions of the different glands are said to

possess distinct properties, the parotid saliva being more limpid and strongly alkaline is supposed to be poured out during mastication, while that from the submaxillary being more viscid, is supposed to assist deglutition. When first secreted it is always alkaline but is soon neutralized by coming in contact with the acid mucus of the mouth. During digestion its alkalinity is ~~more strongly~~ more strongly marked and is said to be in direct proportion to the acidity of the gastric juice. Its action appears to be limited to the conversion of starch into grape-sugar. But although it does possess this power, still it would seem from the fact that its action is necessarily of short duration, that this property of the saliva must be one of

but little importance in the digestive process. It is said not to act upon azotized matters: perhaps the expression, - its action upon azotized matters is unknown —, would have been better; for the experiments of Spallanzani and Reaumur have shown that even nitrogenized matters are more quickly acted upon by the gastric fluid, when mixed with saliva. Notwithstanding all the experiments that have been made we are still left in the dark respecting the chemical uses of the saliva in the human system and are obliged to speculate from our knowledge of its constitution, as to what its action may be. On the other hand, its mechanical functions, in keeping the mouth duly moistened; in facilitating the

motions of the tongue in speaking; in dissolving sapid substances so as to make them susceptible to taste; and in softening and lubricating the food prior to the operation of deglutition; are as easily perceived.

The food now properly masticated and insalivated is prepared to be carried into the stomach. This act is accomplished with the aid of voluntary and involuntary muscular contractions and is called Deglutition. The mass of food is carried by voluntary muscular action, backwards and downwards until it passed the anterior arch of the fauces where it is taken up by another set of muscles, and, nolens, volens, is transmitted through the pharynx to the oesophagus: upon arriving

at this point its presence affords a stimulus to that tube and it is carried by a series of undulatory contractions, to the stomach. Here we must pause in our rapid sketch of the digestive process for we now have before us the organ that will be the most important feature in our investigations. In our Consideration of the Subject thus far, we have not alluded to either of our two divisions of the Subject. The Saliva perhaps from its action upon Starch may be considered as taking a part in calorifacient digestion. But now we come to speak of histogenetic or tissue making digestion.

Next in order in the course of the alimentary canal, we find, situated in the Epigastric and left hypochondriac regions

a large sac called the stomach. This sac we find, upon examination, to be a muscular organ lined upon its internal surface with a mucous membrane and communicating with the oesophagus at its cardiac extremity and with the intestine at its pylorie extremity. The mucous membrane presents a soft, velvetty appearance and when the organ is at rest, is thrown into numerous folds or rugae. Its free surface when examined by the microscope, presents a peculiar reticulated appearance, which is owing to shallow polygonal compartments, at the bottom of which may be observed the small orifices of the gastric follicles. These follicles vary in size from the 1/350 to the 1/250 of an inch, and in depth according to the thickness of the mucous membrane. They are lined with cylinder epithelium

and their office is to secrete the gastric juice. The gastric juice is a slightly yellow, viscid fluid having a decided acid reaction. Considerable difference of opinion has been manifested respecting the acid constituent of this fluid, some physiologists attributing its acidity to hydrochloric and others to lactic acid. The most recent experiments performed in this country have induced an eminent physiologist — F. G. Smith — to believe that the acidity of the gastric juice is chiefly owing to the presence of lactic acid. The animal matter is called Pepsine. It is but sparingly soluble in water and when dried, looks and smells like glue. Like the organic constituents of the other digestive fluids, its action is that of a ferment. Neither the pepsine nor

the acid will perform their peculiar digestive functions separately, but when combined they act with great readiness.

The secretion of the gastric juice is only excited by a stimulus: any foreign body introduced into the stomach, will produce this effect by acting as an irritant. The application of very cold water or small pieces of ice, first produces a pallor which is soon followed by reaction and an increased flow of the juice. The secretion appears to be exactly proportioned to meet the wants of the System; consequently an excess of food would not be met with an increased flow of the digestive fluid. —— Pain in different parts of the body will impede the flow: so also will powerful mental emotions, such as excessive anxiety

grief or joy. We may conclude from this fact that the old adage – A clear conscience is the best nightcap — is philosophically correct; for we can easily conceive the frightful dreams that would be conjured up by an attack of indigestion brought on by the workings of a guilty conscience.

Having watched the progress of the mass of food through the operations of mastication, insalivation and deglutition, let us now turn our attention to the effects produced upon its composition by the fluid of the stomach. The operation carried on in the stomach is called chymification and its result is the changing the food into a dark, thick and apparently homogeneous substance with an acid taste

and smell: this substance receives the arbitrary title of chyme.

The food taken into the stomach is generally composed of a number of different elements and at the termination of its digestion these may be so mixed together in the chyme as to defy recognition: the case of St Martin has done much towards removing the difficulties that had stood in the way of philosophical research until the time of that fortunate accident. A detailed account of the various experiments that have been made upon different articles of food would require a greater amount of time than we think would be expedient to bestow upon it: we shall therefore, having drawn our own conclusions, give them as briefly as possible.

Different conditions affect the digestibility of the food. A state of minute division facilitates the process; the gastric juice soon coming in contact with every portion of the mass: whereas if the food were swallowed in a solid lump the operation would be much delayed as the gastric juice would act only upon the superficial portions. We are here led to consider a fruitful source of sickness in this age, and especially in this country of fast men and women. The business man of the present day often thinks that the time necessarily allotted to taking his meals, is so much to be placed to the debit side in his account of the profits and losses of the day: accordingly he sits down to his table, his mind all the while intent

on buying and selling; bolts his food at a railroad speed, unchewed or at best not more than half-chewed, hurries off to his place of business, and in a short time is attacked with all the horrors of dyspepsia; and to crown all goes to a physician expecting to gain relief while still continuing his abominable practices in eating, fails of course, and, stigmatizing the whole medical profession as a humbug, takes to somebody's never-failing cure for all the ills that flesh is heir to.

Chymification is influenced by other conditions than the nature of the food. The stomach should be moderately filled; over-distension greatly retarding the process. Irregularities in taking the food; over-exertion either before or after a meal;

undue mental excitement from any cause and certain conditions of the general health also exert a prejudicial influence on the process of chymification.

Under ordinary circumstances, digestion in the stomach is completed in about four hours: but the time varies somewhat according to the nature of the food. From the experiments made upon St. Martin, we learn that animal substances are generally more rapidly converted into chyme than vegetables. Certain kinds of animal food are also more quickly acted on than others, as for instance beef is digested quicker than mutton, and mutton than pork &c.

Without entering minutely into an account of the relative digestibility of different articles of food we may state

in a general way that the albuminous principles are so changed by the action of the gastric juice as to be easily absorbed by the lacteals; and that the gastric juice is a necessary agent in effecting such a change.

Neither the amylaceous nor oleaginous principles are acted upon by the gastric fluid: but there is reason to believe that the action of the saliva is continued in the stomach producing glucose and lactic acid from the starch and saccharine matters. —

The gastric juice is aided in its operations by the movements of the stomach. It was formerly supposed that digestion was accomplished by the grinding up of the food by these muscular contractions: now, however,

it is well known that the normal movements of the stomach have for their object the admixture of the gastric juice with the food, and the removal of the chyme from its cavity. Besides these normal movements the attention of physiologists has been drawn to consider the part which the stomach takes in the operation of vomiting. It is stated by some that the expulsion of its contents is effected by the action of the abdominal muscles; the stomach itself remaining passive. The experiments which have been instituted to prove this theory, in our opinion prove nothing more than that the pressure induced by the abdominal parietes might be sufficient to expel the contents of the stomach even if that organ

were to remain at rest. Accident has however revealed to us that the stomach itself cooperates actively in the expulsion of its contents: the stomach has been seen while protruding from a wound through the abdominal walls to contract forcibly and repeatedly, expelling all but its gaseous contents. We have also the evidence of the patients sensations. ——— The diaphragm cannot be said to take an active part in this disagreable operation: it becomes rather a backer affording an unyielding wall against which the stomach is pressed. Relaxation of the muscular fibres forming the Sphincter of the cardiac orifice is necessary: there is no doubt the straining and retching of the first ineffectual attempts at vomiting are owing to the rigidity of these fibres. ———

Experimentation has done but little towards revealing how much the functions of the stomach are indebted to nervous influence for their perfect performance. The abundant distribution of the pneumo-gastric nerves would certainly indicate that some at least of the stomach's operations are controlled by their influence; yet section of these nerves has failed to produce any decisive result.

The experiment made by M. Bernard of administering doses of emulsine and amygdaline to dogs whose pneumogastric nerves had been severed, only proves that the secretion of the gastric juice is only temporarily suspended and that while thus suspended, these two substances will be absorbed unaltered into the blood, and, mixing

there will produce their poisonous effects.
Examination of the stomachs of animals some hours after the section of the nerves has disclosed that the food was only digested upon its superficial portions where it had come in contact with the mucous membrane. From this fact we may conclude that division of the nerves of the stomach only interferes with digestion by paralyzing those motions which are so well calculated to incorporate the gastric juice thoroughly with the mass of food, and after its formation into chyme to expel it through the pylorus. —— The sensation of hunger also evinces in a slight degree the connection of nervous agency with the stomach. This sensation is referred by the mind to the stomach and may

be appeased by the introduction of non-alimentary substances into that cavity. But as the sensation continues to be felt even after division of the pneumogastric nerves which are, as it were, the telegraphic wires through which the brain gains cognizance of the condition of the stomach, a more general want would seem to be indicated. This is shown to be the case by the introduction of nutritious matters into the blood or into the alimentary canal per anum.

We may then assert, that the sensation of hunger is to be referred to a general want of the system but primarily to an empty condition of the stomach.

We have now, briefly, as the nature of the case demanded, gone thus far in our consideration of the digestive

process noticing as we have proceeded the changes induced in the food by the fluids of the mouth and stomach. From what we have seen, we are prepared to assert that the digestion of histogenetic or nitrogenized material is carried on mainly in the stomach, while the calorifacient or non nitrogenized substances, having undergone little or no change, are pushed forward through the pylorus to be subjected to the action of other fluids. It is of the digestion of these substances that we come now to speak. —— Following along in the course that we have laid out, we next encounter a long tube which has been divided into three portions by anatomists, and named, the duodenum, the jejunum and ileum. This tube is about twenty feet in length and has a valve at

each extremity, the pylorie being the valve of entrance and the ileo-coecal, the valve of exit. Like the stomach it has three coats, a serous, a muscular, and a mucous. The surface of the mucous membrane is greatly increased by being thrown into numerous folds termed valvulae conniventes. The folds are very numerous in the duodenum below the orifice of the biliary duct, but grow less frequent from the commencement of the jejunum and at the termination of the ileum they become almost obliterated. They serve to increase the surface to which the chyme is presented, and to prevent its too rapid passage through the intestine. The surface of the mucous membrane is covered with minute processes called villi, and imbedded in its substance are numerous glandular structures which have

received the names of their investigators and are called Brunner's, Lieberkuhn's, and Peyer's glands. — Brunner's glands are found only in the duodenum. They are minute lobulated bodies, resembling the salivary glands in structure and opening upon the surface of the mucous membrane with distinct gland-ducts. — The follicles of Lieberkuhn are simple tubular depressions resembling somewhat the gastric follicles and found scattered over the whole surface of both large and small intestine. — Peyer's glands are only found in the small intestine. They occur in two conditions, either singly when they are called glandulae solitariae or in patches when they are called glandulae agminatae. They may be described as whitish sacculi having no opening into the intestine. By some physiologists these

glands are thought to be a part of the absorbent system. The combined secretion of these glands is called the Succus entericus. The largest share in this secretion is probably due to Brunner's glands. The succus entericus is always alkaline in reaction and not only changes starch as rapidly as saliva and the pancreatic juice but also exerts as powerful influence on flesh, albumen and other protein bodies as the gastric fluid itself. — Besides the organs which belong directly to the intestinal tube, we find opening into the duodenum, sometimes with a common orifice, the biliary and pancreatic ducts. The nature of the fluids poured into the intestine through these ducts is better known and will require a closer investigation. — The pancreas is a long tongue-like body

lobulated in structure, thus resembling the salivary glands, from which resemblance it has received the euphonious title of the belly-Spittle gland. Its secretion however, besides possessing properties in common with the saliva, has other characteristics that indicate the possession of a much wider range of action. It acts upon Starch more powerfully than Saliva, changing it to glucose and lactic acid, and more recent experiments have shown that it possesses the power of forming an emulsion with fatty matters that will not separate on standing. From this fact it is concluded that the pancreatic juice is the main agent in the digestion of fats. This view is well supported by experiments and clinical observation: it having been shown that

if the pancreatic duct be tied or the organ itself be so diseased as to be incapable of performing its functions, fatty or oily matters are discharged from the intestine. —— Entering the intestine by the side of and sometimes by a common orifice with the pancreatic duct, is the biliary duct or ductus communis choledochus. The bile which is discharged through this duct may be described as a slightly viscid fluid of a dark greenish yellow color, extremly bitter taste, and an alkaline reaction. Its uses in the human economy are not distinctly understood. The only effect produced by its agency that we can find substantiated by reliable experimentation is, that by its antiseptic power it prevent decomposition of the food during its passage through

the intestines. Its presence has been found to check the process of fermentation; hence we can understand that a reflux of bile into the stomach would seriously interfere with gastric digestion: also when there is a deficiency in the amount of the secretion or more food is taken than can be acted on by the bile, it is evident that fermentation would continue and be evinced by flatus and sometimes by diarrhaea. — It has been considered to be a natural purgative from the facts that constipation exists in jaundice, from the diarrhaea that follows a too profuse flow, and from the well known purgative properties of inspissated ox-gall. — This would seem to be a favorite view with our theorizing friends of the old school, judging from their practice. Nothing is definitely known

of its action upon different articles of food. Albuminous and amylaceous matters are unchanged by it and the emulsification produced by its admixture with fats is not nearly as perfect as that produced by the pancreatic juice. It might be supposed that the want of a fluid possessing so many properties — none of which are known — would be seriously felt by the human economy; but such is not the fact; the bile duct has been made to discharge the whole of its secretion through a fistulous opening and the animal has survived the operation for a long time.

Experiments have shown that the combined secretions of the liver, pancreas, and intestinal glands possess a much wider range of action than either of them do separately. Besides changing

starch more energetically and emulsifying fats more perfectly than the pancreatic juice, it has the faculty of changing nitrogenized material in the same manner as the gastric fluid; thus partaking of the character of an "universal solvent."

Having thus rapidly glanced at the properties of the different digestive fluids that are poured into the intestine and also noticed their increased power when in combination, we will now proceed to note some of the changes induced in the food when submitted to their action.

In our descriptions of the nature of the intestinal digestive fluids we were obliged to make mention of their action upon different alimentary prin-

ciples and for this reason we shall be very brief in what we are about to say concerning their combined action. Before we proceed, however, we must remark that the information which has been gained, seems (to us at least,) not entirely satisfactory. The student of Physiology in his investigation of these phenomena may well sigh for the occurrence of another fortuitous circumstance similar to that which happened to St. Martin. For the present we must trust to experiments performed out side the body. We have reason to believe that the ~~experiments~~ peculiarities exhibited in artificial experiments occur, - ceteris paribus, - in the small intestine.

We will now proceed to notice

briefly the changes induced in the chyme.

The acid chyme soon after reaching the duodenum becomes alkaline and changes in appearance from a dark, homogeneous mass to a whey-like fluid having a creamy pellicle and a dark, reddish sediment. The whey-colored fluid is probably composed of nitrogenized material that has been acted upon by the gastric juice, the creamy pellicle of fatty matters, and the sediment of the insoluble portions of the food. Whatever nitrogenized material has escaped the action of the gastric juice, as we have said before, is changed by the combined intestinal fluids in their character of an "universal solvent."

Fatty and oily matters are emulsified probably more through the influence of the pancreatic juice than that of either of the

other intestinal juices. —— Starch is changed into dextrine and glucose, and it is inferred from the fact that animals will fatten upon potatoes &c, that fat is produced from the starch which forms the principal ingredient in their composition. —— Sugar when taken as food, being readily soluble in water, is for the most part absorbed from the stomach; but whatever portions escape into the intestine, are there changed into glucose, which with the glucose formed from starch eventually becomes lactic acid. ——

By the peristaltic movements of the intestine the food is forced along the canal. During its passage the now thoroughly prepared chyle is absorbed through the villi into the lacteals, from whence it

is to pass into the circulation to be distributed to the body. — The soluble portions of the food being absorbed the remainder which constitutes the faeces is pushed along into the large intestine which acts as a reservoir: here it is retained until the desire to expel it is manifested.

The muscular fibres of the large intestine are wholly out of the control of the will, but the escape of the faeces is prevented by the closure of the Sphincter ani muscle. —

Expulsion is finally accomplished "principally by a contraction of the diaphragm and abdominal muscles upon a full and sustained inspiration, the glottis being closed so as to prevent the escape of the air contained in the lungs".

Having thus concluded our hurried and imperfect sketch of the digestive process, let us ask ourselves the question, of what practical importance is the acquisition of all this knowledge? The question is easily answered: without understanding the condition of these organs in a state of health, how are we to know when their functions are deranged? But we will go further: we consider a healthy digestion essential to the perfection of humanity; to the development of the physical, intellectual and moral man in all the fullness of vigor and beauty. — Without it he is physically a complaining invalid, mentally a hypochondriac, and morally a victim

of fears and doubts, if not of despair. -a fit inmate of John Bunyan's doubting castle.—. The surly "old Cassius", always snarling, always plotting, and, upon the turn of fortune committing suicide, presents himself to our view with his "lean and hungry look", an excellent picture of a confirmed dyspeptic.

How different is the condition of that man whose digestive functions are perfectly and regularly performed. To describe such a man we cannot do better than to use the words of the immortal Shakspeare; ——

See, what a grace was seated on his brow:
Hyperion's curls; the front of Jove himself;
An eye like Mars, to threaten and command;
A station like the herald Mercury,

New-lighted on a heaven-kissing hill;
A combination, and a form, indeed,
Where every god did seem to set his seal,
To give the world assurance of a man. —

Finis